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ABSTRACT

Throughout history, there has been controversy about the origin of the variety of life on earth. The sciences of evolution and taxonomy are intimately tied to this controversy. This booklet considers time, space, and spirit related to evolution. Time refers to a sense of history; space refers to geography; and spirit refers to life and thought. Several chapters on the history and concepts of evolution and systematics, a time line related to the concepts, a map of the important geography related to these concepts, a glossary of important terms, and a list of several study suggestions are included. (CW)

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Evolution

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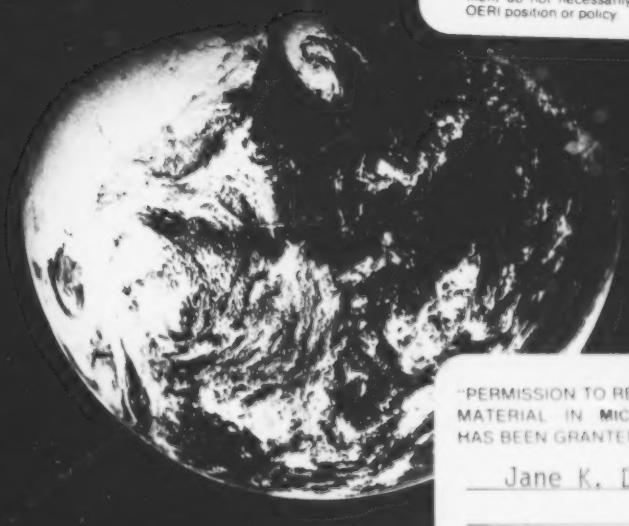

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A HAWKHILL LEARNING POWER BOOK

2

TIME, SPACE AND SPIRIT

KEYS TO SCIENTIFIC LITERACY

To the student,

This short book will help you understand our modern world. It has changed a lot since your parents were born. Even more since you were born. And it will change still more–much more–in your lifetime.

What is behind most of these big changes? Two things. Science and technology.

What can you do about it? The first step is to understand more about science and technology and how they connect with our world. Especially the ever-growing world of free democratic societies. One way to do this–the way this book follows–is to look at the world from three angles: *Time, Space* and *Spirit*.

Time means history. You can learn how science and technology have worked in the past and are working today.

Space means geography. You can learn where important things happened in the past and are happening today.

Spirit means life. The life of the mind. You can learn the key words, concepts and ideas that power science and technology (and society) today.

This book teaches about science, technology and society from all three of these angles–*Time, Space* and *Spirit*.

Read on.

This book belongs to:

Evolution

Bill Stonebarger
Illustrations by Lin Haley

Hawkhill Associates
Madison, Wisconsin

This book is one of a series of sixteen Learning Power Books in the *Time, Space and Spirit–Keys to Scientific Literacy* series. It is designed to accompany the video program of the same name.

The *Time, Space and Spirit–Keys to Scientific Literacy* series was written and produced with consultation from the History of Science Department at the University of Wisconsin-Madison.

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Part 1: The Idea of Evolution–A History

a science teacher on trial

The time is 1925. The place, Dayton, Tennessee. In the Rhea County Courthouse the two most famous lawyers in America argued for and against a seventy-year-old scientific theory called evolution by natural selection.

On trial was a young high school science teacher named John Scopes. Scopes, it was charged, taught his students that living things had evolved over millions of years from more primitive ancestors. Scopes believed and taught that man was descended from the monkeys, charged the prosecution's lawyer, the famous William Jennings Bryan.

called the "monkey trial"

Such a view, claimed Bryan, was absurd, was contrary to Holy Scriptures and was against the law in Tennessee. (In the popular press the trial was called the "monkey trial.")

Clarence Darrow for the defense

His opponent, the famous defense lawyer Clarence Darrow, argued that the Darwinian theory of evolution by natural selection was the most reasonable explanation for the variety and similarity of life on earth. Furthermore, said Darrow, the Tennessee law was unconstitutional since it prohibited free speech and put religion into the state's public schools.

international sensation

The Scopes trial became an international sensation in 1925. Reporters from all over the world crowded the small town in Tennessee to record the drama for their readers. People in Dayton, and all over the world, took sides in the controversy. One poll of the day found the courtroom crowd equally divided, for and against evolution.

Scopes found guilty

The trial's outcome was something of an anticlimax. Scopes was found guilty of breaking the Tennessee law against the teaching of evolution and was fined $100. The conviction was later overturned on a legal technicality. The sensational publicity of the trial, however, served to make a hero out of Scopes and hold Bryan and the cause he represented up to a good deal of ridicule. Bryan himself, broken in health and spirit, died in his sleep only a few days after the trial's verdict in a front parlor in Dayton.

conflicts over evolution

The Scopes trial was the most famous. There have been many other conflicts the past 150 years over

the scientific theory called evolution by natural selection. Some of these conflicts have been scientific ones, but many have been political and religious as well. Let's look at the world history of this idea, one of the handful of scientific concepts that are keys to scientific literacy today.

great variety of plants and animals

People from ancient times could not help noticing there was a great variety of plants and animals in the world. For the most part most people were too busy trying to survive in competition or cooperation with these other living creatures to give much thought to why there were so many. And to how they got to be the way they were. In some ways so like humans and in so many other ways so very different.

why so much variety?

To those who did have the time or inclination to speculate about such questions, the most common answer was that a god or gods made them that way. Many also believed that the same god or gods made other living creatures to please and serve mankind.

first scientists

In the ancient Ionian cities of Greece (now in ruins on the western coast of modern Turkey) some of the world's first scientist/philosophers dared to ask and answer questions like this in a different way.

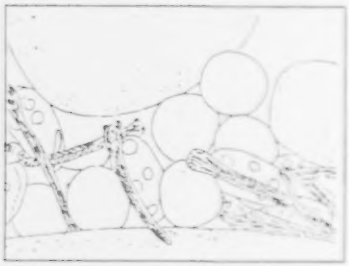
Anaximander's theory

Anaximander in 550 B.C. proposed a theory of evolution to explain the variety and likenesses among living things. All life, he said, has come from early life in the water. Over long periods of time, the

water creatures crept out on the land, developed legs, then fur and finally human forms. Anaximander did not have much evidence to support his theory, nor did he have any ideas just how this kind of near miracle could have actually taken place.

how many species are there?

One of the handicaps early thinkers had was massive ignorance about living things. They knew of the existence of only a tiny fraction of the variety of plants and animals that live on this earth. Aristotle, one of the first to invent a scientific classification, found room for about 500 species of animals. As late as 1600 only 6000 species of plants were known. By way of comparison, today over 2 million species of living things have been described.



science of biology slow to develop

In the high days of Renaissance science, when giants like Copernicus, Galileo and Isaac Newton were shaking the foundations of human knowledge about the earth and its place in the solar system, biology was in its infancy.

discovery of microscopic world

True, men like Vesalius and William Harvey were disproving some ancient misconceptions about the way the human body was built. The Dutch lens maker, Leeuwenhoek, was the first to view the wonder world of microscopic "little beasties." Still, little progress was made in developing any unifying ideas or in accurately describing and classifying knowledge about the complex living world.

exploration of world

In the eighteenth century, about the same time the American colonies were beginning to change into the United States, humankind's store of knowledge about this complex living world began to

rapidly increase. Explorations into the far corners of the world were becoming more and more common. Many of the explorers were returning with specimens of new species of plants and of animals never before known to western scientists. And more and more men were becoming scientists. In those days there were few if any professional scientists–that is, people who made a living searching for answers to questions about nature. So it was that "amateur" scientists like our own Benjamin Franklin and Thomas Jefferson were among the first of the human race to devote their skills to the scientific study of living creatures.

Carl Linnaeus

One of the most important of the early pioneers was Carl Linnaeus of Sweden. Linnaeus, unlike most early scientists, was a poor boy. He hated school but he loved plants. As a young university student, poor and hungry and plagued with gout, he left on a field trip to Lapland to collect plant and animal specimens. The 4,600 mile trip cost him only $100. The knowledge he gained on this trip paid off handsomely for all of us.

new classification system

A few years after his trip in 1735 Linnaeus brought out his first book, *Systema Naturae*. It was a great scholarly hit and he became an instant celebrity. In this book he proposed a classification system for plants and animals that is still being used today.

binomial nomenclature

All living things, suggested Linnaeus, should be grouped according to a natural and logical system he proposed. Each kind of living thing would be given a unique double name in internationally accepted Latin. First would be its genus. Followed by its species. It was called a binomial nomenclature system.

order and system to biology

Similar genera would be grouped together into families; families into orders; orders into classes; classes would be grouped into a few major phyla; and finally, phyla into kingdoms. It was a system that for the first time brought order and system into the study of the living world.

opposed idea of evolution

Linnaeus helped people see the reality of living species but he himself opposed the idea that living species had ever evolved from common ancestors. He saw his work of inventing and promoting the present classification system as the scholar's humble way of "tracing the footprints of the Creator."

Others of the eighteenth century, however, began to speculate on the possibility of change in the living world. On the possibility of evolution.

an elegant Frenchman

One of the most important was a Frenchman, Georges Buffon. A charming, elegant man of great wealth, Buffon was able to devote his life to scientific study without worry of earning a living. He founded one of the first genuine biological research centers in the world, the Jardin de Roi (Garden of the King) in Paris. He is said to have started his work day at 6 a.m. each morning, taking two breaks each day to have his hair dressed and powdered. In between many love affairs and a few duels, he managed to write forty-four volumes of natural history. These volumes summarized all that was then known about the natural world. In some of these volumes he anticipated

many of the ideas of Darwin and later evolutionists, but he never quite put together a convincing theory to explain the mechanisms of evolution.

conflict with church

The books were convincing enough to the religious authorities, however. They brought him before the Syndic of the Sorbonne in 1751 where he was commanded to withdraw portions of his books that seemed to contradict Holy Scriptures. One of the parts the religious authorities most objected to was Buffon's estimate of the age of the earth as on the order of 100,000 years. Biblical doctrine held that the earth was created in 4004 B.C.

Lamarck and a new theory of evolution

Another Frenchman, Jean Baptiste Lamarck, built on the foundations laid by Buffon to construct one of the first fully formed, genuinely scientific theories of evolution. As poor as Buffon was rich, Lamarck took over the Jardin de Roi when it became the Jardin des Plantes after the French revolution. (Which revolution also executed Buffon's aristocratic family.) Teaching himself zoology after the age of fifty, Lamarck proposed a theory of evolution which he said reflected the natural order of animals in nature. Its key ideas were two: nature has an innate tendency to evolve in the direction of increasing complexity, and acquired characteristics will be passed on to offspring. In this way nature will slowly move toward increasing variety and complexity to fill up all the niches in the living world.

coins a new word

Lamarck also has the distinction of being the first to coin and use the word "biology."

Georges Cuvier

Paradoxically, one of the Lamarck's most critical scientific opponents, the anti-evolutionist Georges Cuvier, laid even more important groundwork than did Lamarck for the later flowering of the Darwinian evolution theory.

paleontology becomes a science

Cuvier worked at the same Museum of Natural History in Paris in the late eighteenth and early nineteenth century. He is credited with founding the science of paleontology–the study of plant and animal fossils.

explaining fossils

Before Cuvier, fossils were known but little understood. The most common view was that fossils were freaks of nature placed there to amuse and mystify humans. Cuvier spent many years systematically studying fossils found in the limestone deposits around Paris, as well as those brought to the Museum from all over the world. He compared the forms left in the rocks with the anatomical structures of living creatures of his day. He became the world expert in reconstructing an entire animal from a few fossil bones. And he concluded from his study that fossils were prints of former creatures, prints that had been made in great catastrophes of the past, the greatest of which was the flood described in the Bible when Noah built his ark.

founder of modern geology

The opposite geological view was taken by the Scotsman generally given credit as being the father of modern geology, James Hutton. Hutton viewed the earth as having no "vestige

of a beginning, no prospect of an end." He saw earth as changing in the past, changing today and changing in the future. Changing very slowly but surely over very long periods of time from the same geological processes you could see happening today. Mountain building, erosion, volcanoes and earthquakes.

Charles Lyell

Hutton's ideas were advanced and popularized by Charles Lyell, whose book *Principles of Geology* became the first classic work in geology and an important influence on biology as well.

an English gentleman, Charles Darwin

By the mid-nineteenth century ideas about the possible evolution of living forms were widespread, but no one had yet convincingly demonstrated how it could have happened. The man deserving the most credit for doing so was an English gentleman, Charles Darwin.

around the world on HMS Beagle

Darwin as a young man was not considered promising. His father once told him "you care for nothing but shooting, dogs and rat-catching, and you will be a disgrace to yourself and your family." When he got the chance to go on a round-the-world voyage as a young unpaid naturalist he snapped up the opportunity. The rest is history. Darwin's five-year voyage of discovery on HMS Beagle changed the world.

The Origin of Species

Here is the way he cautiously, but accurately, summarized the voyage in the first sentence of one of the most famous works of science of all time, *On The Origin of Species by Means of Natural Selection.*

"When on board HMS Beagle, I was struck with certain facts in the distribution of the organic beings inhabiting South America, and in the geological relations of the present to the past inhabitants of that continent. These facts seemed to throw some light on the origin of species–that mystery of mysteries."

a study in England

When Darwin got back to England his health was broken. He married, though, and had a large family. Fortunately he inherited wealth from his family and did not need to earn a living. Instead he settled in a country home in Down, just south of London to a life of quiet study.

evolution by natural selection

On his daily walks behind the house overlooking the quiet English countryside Darwin gradually pieced together his theory of evolution by natural selection, the theory of evolution that in broad outline is still accepted today as one of the bedrocks of modern biology.

Alfred Russel Wallace

As so often happens in science, at almost the same time another man was coming to much the same theory. That man was Alfred Russel Wallace. In outline Darwin and Wallace's theories were almost identical and surprisingly simple. In nature, they said, living creatures have more offspring than can possibly survive. The result is a struggle for existence. Since offspring vary, some will

be more fit than others to survive. These survivors will pass on their useful traits to their offspring. Thus, in time, nature will select the most fit to survive. And, much as a gardener artificially selects traits he wants to survive in his plants, or as a cattle breeder selects traits he wants in his cattle, nature's selections will create whole new kinds of living things. New species.

famous books

Darwin's book *On the Origin of Species by Means of Natural Selection* and his following book *The Descent of Man* piled one piece of evidence on another to illustrate and support his theory. And this evidence was so overwhelming it convinced most scientists all over the world.

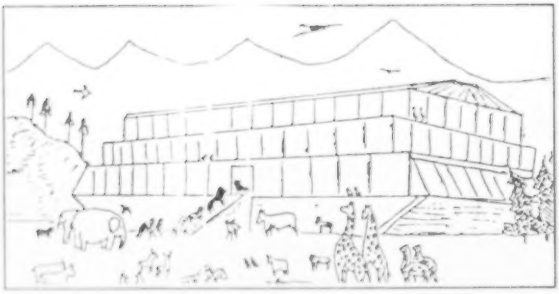
controversy then and now

Not everyone was convinced of course. In his day or in ours. In his day Darwin was ridiculed unmercifully from the pulpit and in the popular press. Also from some scientists.

creationism

Waxing and waning, controversy over evolution has continued in our own day. Most scientists and many people of all faiths now accept the Darwinian theory of natural selection in broad outline. Some will add, however, that behind the scenes of organic evolution, it is God who is responsible for the living ascent, and most especially for the human soul. Others hold to a literal interpretation of the Bible and insist that all species were created at one time, with many being destroyed in one great catastrophe, the Biblical flood.

Some of these fundamentalist Christians have recently organized to search for scientific support



for their Creationist views. They have also initiated court suits and legislative bills to force the public schools to give equal time to Creationist points of view.

disagreement in scientific community

Within the scientific community, too, there is disagreement about evolution. Not about the fact of evolution but about the details of natural selection.

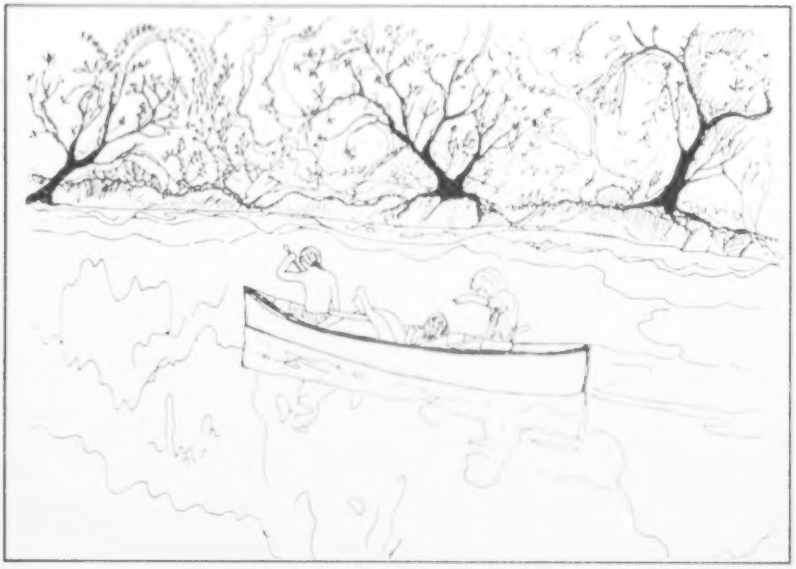
social and political implications

And certainly of all scientific theories, the theory of evolution by natural selection has not only been the most controversial for the general public, it has also spawned the most varied social and political spin-offs. Capitalism, socialism, communism, fascism, racism, manifest destiny, progressive education and more. All claim descent and support from the theory of evolution by natural selection of Charles Darwin and Alfred Russel Wallace.

Who is right? Who is wrong? Some say it is hopeless, we can never know these things. Others say we already do know, and it is this way.

Read on to Part Two of this book to learn details of present day evolution theory and of the controversies that accompany it.

Part 2: Evolution by Natural Selection.



a poet celebrates the world

"Glory be to God for dappled things
for skies of couple-color as a brindled cow;
for rose-moles all in stipple upon trout that swim;
fresh-firecoal chestnut falls, finches wings ...
Whatever is fickle, freckled (who knows how?)
with swift, slow; sweet, sour; adazzle, dim;
He fathers forth whose beauty is past change;
Praise Him!"

That's how the poet, Jesuit priest and classical scholar, Gerard Manley Hopkins, celebrated the living world in 1877.

a scientist explains the world

The same living world that his neighbor, Charles Darwin, English gentleman, father and scientist, had just explained (and celebrated) in two books that have become classics of science, *On the Origin of Species by Natural Selection*, and *Descent of Man*.

differences and likeness

To understand the differences (and the likenesses) between these two approaches to truth, let's first look at Darwin's contribution. His theory of evolution by natural selection is one of a small number of key scientific concepts needed to make sense of our modern world.

why so many species?

There are over two million different species of plants and animals on earth today. Why are there so many? And why, despite this incredible variety, are all living things so much alike in their basic chemistry? Alike in their living structures and alike in their ways of surviving and reproducing?

relation to fossils?

And finally, how are today's living things related to those other living things whose fossil remains are found so abundantly all over the world?

evolution by natural selection

The theory of evolution by natural selection answers all of these questions this way:

1. Living creatures have more offspring than can survive.

2. There is variation in these offspring.

3. Some variations give an advantage and some make for a disadvantage in an inevitable struggle for survival.

4. The more fit will survive and pass on their desirable traits to their offspring.

5. In this way living things will change. Given enough time, whole new species of living things will evolve upon this fruitful earth.

a scientific theory

It sounds simple. And it is. That is part of the beauty of any good scientific theory. It accounts for a wide range of individual events, using a bare minimum of general principles. Simple or not, what evidence is there to support this theory?

Answer. A great great deal. And from many many different scientific disciplines.

nature's history book

First, and perhaps most important, there is the fossil record itself, nature's history book.

Fossils are the records in stone inadvertently left by living creatures of the past. Some are imprints of leaves, footprints, bones or dropppings that have been covered over by sand or mud, and hardened into rocks that have survived for millions of years.

Sometimes we have actual fragments of plant and animal parts–pollen grains, teeth, bones, etc. Comparing these fragments to other similar structures in living organisms today, and with the knowledge that modern anatomy, physiology, geology, physics and biochemistry can provide, paleontologists have

been able to construct a record of life in the past, as remarkable for its detail as for its drama.

the fossil record

Here are some highlights of that record–that world history–that are generally agreed upon by almost all experts who have carefully studied the fossil evidence.

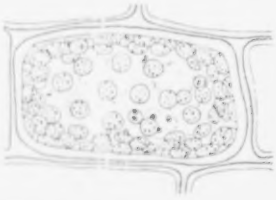
early life in the ocean

The oldest fossils we have been able to find and identify come from rocks that were formed about seven hundred million years ago. In those days life was only found in the ocean. It apparently had been that way for over three billion years before that.

3 billion years of changes

During that three billion years, however, life had branched, had changed, had evolved into many thousands, perhaps millions of different species. Each species had its own particular skill, its own particular advantage in the life struggle.

plants begin



Some species developed a chemical process to make use of direct sunlight as a source of life energy. Today we call that process photosynthesis. These organisms were the ancestors of all our modern plants.

animals begin

Some species developed ways of moving, of capturing food, of digesting food, of sensing light, heat and sound. These organisms in the ocean were the ancestors of our modern animals–fish, frogs, grizzly bears and human beings.

the same chemicals of life

One of the clearest proofs we have that all of us, oak trees to frogs to human beings, have evolved from these common ancestors in the primeval ocean is the astonishing similarity in all of our life chemistries.

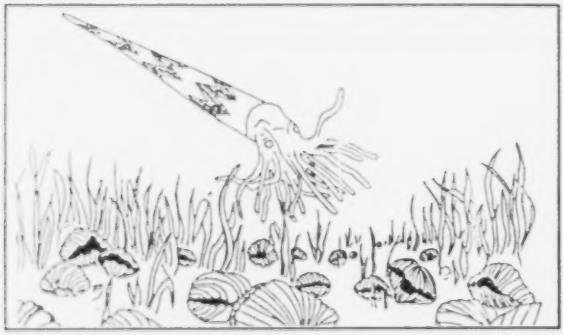
Whether you happen to be an oak tree or a frog or a human being, if we chemically analyze what you are made of, we find the same basic elements, compounds and mixtures. And always in very similar saltwater suspensions!

in a salt water suspension

Most amazing of all, that saltwater suspension is very similar to the saltwater content of the ancient ocean! It can give you an eerie feeling to taste your tears, or the sweat from your brow, or the blood from your cut finger, and suddenly realize that the salty taste comes from the "ocean" you still carry around inside you. The same ocean your single-celled ancestors lived in so long long ago!!!

many-celled creatures

Sometime around six hundred million years ago the seas began to teem with many-celled creatures. Cells had learned to clump together, and to specialize. And to make strange looking creatures like trilobites, snails and sea scorpions.



vertebrates appear

Another hundred million years go by and the variety increases. We find fossils of creatures that are direct ancestors to modern octopus, squid and horseshoe crab. Wait another hundred million years and the first vertebrates–animals with backbones–appear.

life moves onto land

About four hundred million years ago life first began to take the giant step onto land. Plants were the first pioneers, creeping out in inconspicuous ways like modern rock-hugging algae, mosses and liverworts. Animals followed. Insects, scorpions, and finally the first land vertebrates, lungfish and amphibians.

dating fossils and rocks

When we trace life history this way, it is not just imaginative speculation. We have millions on millions of fossil imprints of these creatures. And we have many ways of geologically dating the rocks these fossils are found in. Radioactive decay, geological strata and new sensitive chemical techniques are examples.

facts or theories?

Many scientists would prefer to call this story of life changing on earth a fact, not a theory. That the changes occured is as well-documented as anything can be in this uncertain world. The theory comes along to explain how the changes could have occured the way they did.

Age of Reptiles

Once life successfully made the step onto land and learned to use free oxygen in the atmosphere for respiration, life also began to develop thousands of new variations. The Age of Reptiles began with small scale-covered creatures and accelerated into mammoth dinosaurs. And split off into winged creatures that one day would lead to

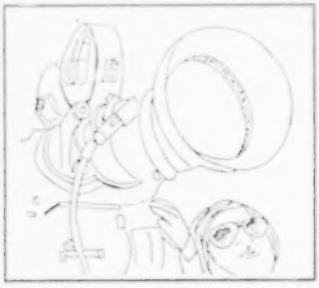
the whole gorgeous tribe of modern birds. This was also the age of giant fernlike trees that, in dying and decaying under ancient swamps, would one day be covered by sand, compressed and altered by heat and pressure into what we today mine as coal, oil and gas.

first birds

By two hundred million years ago the first birds do appear. And only sixty-five million years ago we first see the fossil remains of furry creatures with milk glands who gave birth to live young– the first mammals.

a time-lapse movie

To get these enormous time scales into perspective, imagine you are making a time-lapse motion picture of the progress of life on this planet. Let each second of your movie show twenty-four years of life. On this scale 1,440 years will flash by in one minute; 86,400 years an hour; two million years a day. To show the story we are just telling, start some 730 million years ago in the ancient ocean. Your movie will then last one solid year, showing it nonstop twenty-four hours a day. Start the movie on New Years day.



trilobites appear

The trilobites will first appear on the screen in early spring. By the end of May, fish will swim by. Not till midsummer will we see land animals and plants begin to test the free air.

dinosaurs–the superstars

In September, October and November the most spectacular actors in our movie appear–the dinosaurs. These improbable, incredible creatures dominate our screen for three months! This is called the Mesozoic era. It lasted over 160 million years. And then suddenly the dinosaurs all mysteriously disappear in early December.

mammals take over

The stars now become the mammals, with brains superior to anything that has come before. By the middle of December we will see monkeys, apes and other primates. But it will not be until the very last day of our year-long movie that anything resembling a human being appears.

ancestors of humans

The fossil finds of very early human beings are multiplying every year so the details of the final three million years of life history are being revised often. We know that there were quite a few human types. Neanderthal, Cro-Magnon, Pithecanthropus, Homo erectus and our own Homo sapiens.

Homo sapiens

Homo sapiens, "man the wise," did not appear until about forty thousand years ago, a mere half-hour before the end of our movie. These people, our direct ancestors, slowly learned to cooperate in the hunt, in the gathering and preparation of food, in communicating

in language, and finally in becoming fully conscious of their unique place in the living world.

consciousness enters the world

This final conscious stage may not have happened until very recently in earth history–some scholars say not more than five or six thousand years ago, during the time of the early civilizations, two or three minutes before the end of our movie! And then in that final three minutes what a climax!

ancient civilizations

The Egyptians, the Babylonians, the Chinese, the Indians, the African civilizations rise and fall. Some brave thinkers along the shores of the Mediterranean in Ionian Greece begin to ask the first scientific questions, and give scientific answers.

a fast trip

One minute to go. Jesus Christ is born. Twenty seconds to go. Columbus discovers America. Seven seconds to go. The Declaration of Independence is signed in Philadelphia.

to today

Three, two, one second–electricity, automobiles, power plants, jet planes, and space satellites zoom across the screen.

and you

Leading to the most momentous event of our entire movie. Less than one second before the end of the movie you are born. The latest and thus far most promising experiment of life on this small planet we call earth.

how did it happen?

That is what happened. How did it happen? How can you explain it?

1. Living creatures have more offspring than can survive.

2. These offspring have variations one from another.

3. The variations of one give it an advantage over another in a struggle for existence.

4. Those organisms with the most useful variations will survive and pass on their useful variations to their offspring.

5. Given enough time, and our movie shows how much time there has been, life will branch and branch and branch some more and some more and some more–until we have what we have today.

agreements and disagreements

And is that the whole story then? And do all agree? No. There is much disagreement today about evolution. And much new research actively proceeding.

uncertainty in science

The disagreements are of two sharply contrasting kinds however. Scientifically there is disagreement and uncertainty about some of the details of earth history and of the Darwinian theory, though there is broad agreement about the overall picture.

punctuated theory of evolution

Steven Jay Gould, for example, has been the leading figure in investigating and presenting what he calls a "punctuated" theory of evolution. This is in contrast to the more traditional "gradualism" theory. He interprets the evidence in favor of sharp changes in an evolutionary branch rather than slow continuous variations. These sharp changes could come by mutations in genetics combined with changes in the environment.

mutations

Mutations themselves–sudden changes in the molecular genes of a living organism–are under much active study today. We can see evolution go-

ing on remarkably fast today in the cases of bacteria changing to become immune to our latest antibiotic. Or of insects changing their hereditary structures to escape the harmful effects of our latest insecticide. Or of some species moving to fast extinction because they could not cope with our latest environmental reconstruction.

cultural evolution?

There is also much disagreement over the role of natural selection when it comes to cultural evolution. What role, if any, has it had in racism, sexism, political and social changes? What role, if any, should it play?

Besides the churning of scientific disputes, there is today, as there was in Darwin's time, a bubbling of conflict between religious beliefs and evolutionary ideas.

scientific creationism

Modern "scientific creationists" dispute the entire evolutionary picture presented here. In its place they have their own interpretations which place heavy reliance on ideas of geological catastrophes in the recent past, specifically the Biblical flood. The overwhelming concensus of professional biologists, geologists and paleontologists is that the Creationists are simply mistaken about this. Recent court cases have ruled that "scientific creationism" is religion, not science.

ultimate meanings?

On the other hand, there is no concensus at all among scientists or nonscientists about the broader issues that often transcend science. Is there, for instance, some deeper spiritual meaning expressing itself through the evolutionary process? Does life itself have a role in the seemingly cold universe? Does God stand behind the drama of life on earth and in the universe? What is the ultimate meaning of life on earth?

a plea for tolerance

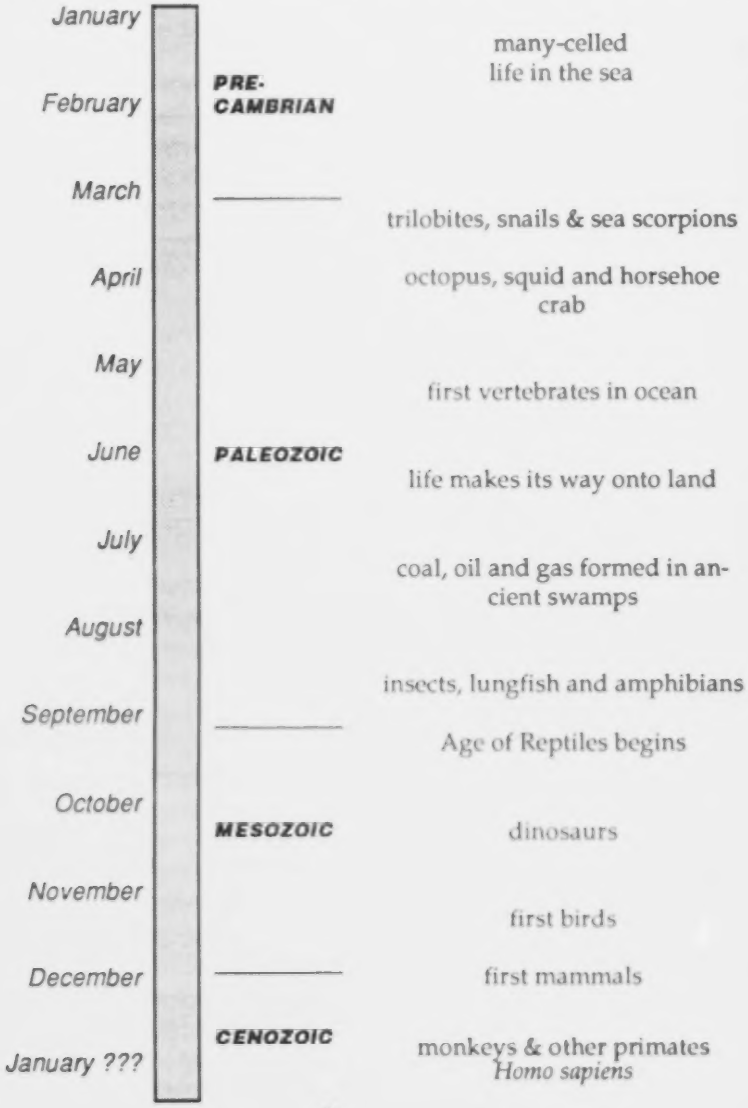
This modest book cannot pretend to answer these questions. It can enter a plea for tolerance, however. Where no one can be certain, all must be free to search, to learn new meanings one from another. Make such a search yourself.

TIME ...

To understand the world of today it helps to know something about the world of yesterday. Kings and queens, wars and famines, presidents and paupers have all played a part. But more important than any of these in changing the past world into the world of today has been science and technology. The time line below will help you place important events and people in historical time.

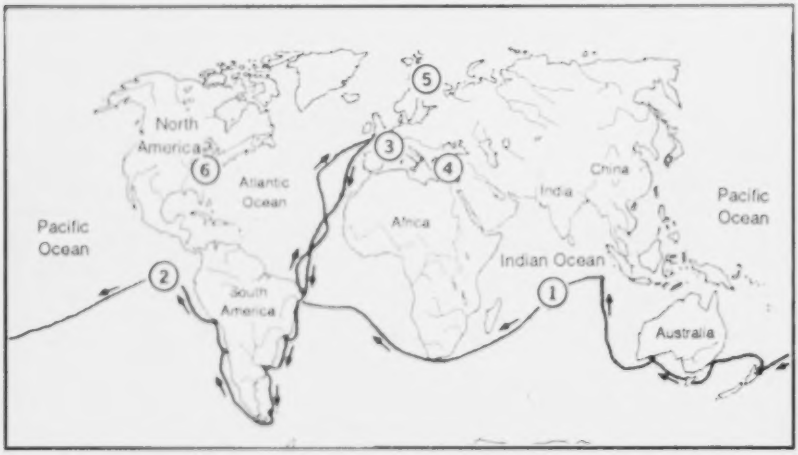
EVENTS IN WORLD HISTORY		EVENTS IN SCIENCE & TECHNOLOGY
	1600	*1600*
1616 death of Shakespeare		
		1677 Leeuwenhoek discovers a new microscopic world
	1700	*1700*
		1735 Linnaeus classification
		1745 Buffon suggests earth is 100,000 years old
1776 American Revolution		
		1793-1826
	1800	*1800* **Lamarck and Cuvier work on fossils and evolution**
		1831-1836
1861-65 Civil War		**Darwin travels around the world on HMS Beagle; leads to *Origin of Species by Natural Selection* in1858**
	1900	*1900*
1914-18 World War I		**1925 Scopes "Monkey Trial" in Dayton, Tennessee**
1939-45 World War II		**1960-present punctuated evolution**

The time line below summarizes 730 million years of earth history. Imagine you are making a time-lapse movie in which each second of your movie shows twenty-four years of life on earth. On this scale 1,440 years go by every minute, 86,400 years an hour, two million years a day. The entire movie will take one year to show. It begins January 1.



SPACE ...

There is a saying, "If you don't know where you are going, any road will get you there." One of the important parts of knowing where you are going is a knowledge of geography. The map below will help you to locate the important events and people discussed in this book.



1. Route of HMS Beagle — Charles Darwin sailed around the world on HMS Beagle as an unpaid naturalist. His explorations eventually led to construction of a new theory of evolution.

2. Galapagos Islands — One of the most productive stops on Darwin's voyage. Many examples of the effects of isolation on the evolution of species can be seen.

3. Paris, France — Where Buffon, Cuvier, Lamarck and others advanced paleontology and evolution theory.

4. Ionian Greece — Site of early civilizations where world's first philosopher/scientists lived and worked.

5. Lapland — Where Linnaeus went on field trip and invented new classification system for biology.

6. Dayton, Tennessee — Site of Scopes "monkey trial" in 1925.

SPIRIT...

Time and space are meaningless without spirit. Spirit is the part in each of us that understands. The part that sees connections between words and things–connections that surprise and make sense. Study the key words, concepts and ideas below so that you can understand how time, space and spirit have worked in the past–and are working today.

amphibian Vertebrate that lives part of its life cycle on land and part in the water. (p. 18)

binomial nomenclature A system invented by Linnaeus to give each species of plant and animal a unique name. Genus first, species second. (p. 5-6)

creationism A theory as to the origin of the earth and of life that claims the earth is no more than ten thousand years old. (p. 11, 23)

Darwin, Charles An English naturalist who proposed a theory of evolution by natural selection. (p. 5-7)

fossil Imprints of living things of the past preserved in rocks. (p. 8, 14-16, 18)

genus A grouping of related species of living things. Similar genera (pl.) are grouped into families; families into orders; orders into classes; classes into phyla; phyla into kingdoms. (p. 5-6)

heredity Passing on traits of a living organism to its offspring. (p. 10, 14, 22)

Homo sapiens Genus and species of modern humans. (p. 20)

Linnaeus, Carl A Swedish biologist of the eighteenth century who invented our modern system of scientific classification. (p. 5-6)

mammal The class of vertebrates that has hair, mammary glands and gives birth to live young. (p. 19-20)

mutation A sudden change in genes that causes a hereditary variation in the offspring. (p. 22-23)

natural selection The process where nature decides which organisms are best fit to survive and reproduce. First proposed by Charles Dawin in *On the Origin of Species by Means of Natural Selection.* (p. 10, 14-15, 21-22)

primate An order of vertebrates that includes monkeys, apes and human beings. (p. 20, 26)

species A particular kind of living thing that can reproduce with other members of its own kind. (p. 4-5, 14-15, 23)

struggle for existence The competition for food, space and other living needs in nature. (p. 10, 14-15, 21-22)

survival of fittest In nature, the result of evolution where the species most able to survive do. (p. 10, 14-15, 21-22)

theory In science, an explanation that best fits the evidence and is successful in predicting results of future experiments or events. (p. 12, 15, 18, 22)

In addition to the above, *Evolution* also teaches about other important people, places, things and ideas. Often you can figure out the meaning of a new term by seeing how it is used in context. Make sure you know the meaning of the following (for help, check the pages listed in this Learning Power Book, as well as your dictionary and encyclopedia):

Aristotle (p. 4); **Bryan, Wm. Jennings** (p. 1-2); **Buffon, Georges** (p. 6); **Cuvier, Georges** (p. 7-8); **Darrow, Clarence** (p. 1-2); **dinosaur** (p. 8, 18, 20); **Gould, Stephen Jay** (p. 8); **HMS Beagle** (p. 9-10); **Hutton, James** (p. 8); **Ionian Greece** (p. 3, 21); **Lamarck, Jean** (p. 7); **Leeuwenhoek, Anton van** (p. 4); **Lyell, Charles** (p. 9); **monkey trial** (p. 1-2); **Neanderthal** (p. 20); **paleontology** (p. 8); **photosynthesis** (p. 16); **Rennaissance** (p. 4); **reptile** (p. 18); **Scopes, John** (p. 1-2); **trilobites** (p. 15); **vertebrate** (p. 18); **Wallace, Alfred Russel** (p. 10).

STUDY SUGGESTIONS ...

1. This book claims that the fossil record shows evolution to be a fact and not a theory. The theory comes in to explain *how* evolution occured. Investigate and discuss the differences between scientific facts and scientific theories.

2. People often think of scientists in terms of personality stereotypes. Read short biographies of some of the scientists discussed in this book, and compare backgrounds and personalities.

3. Investigate the differences between a punctuated theory of evolution and a gradualism one. Also how both of these differ from scientific creationism.

4. This book uses a time-lapse motion picture as an analogy to visualize long time spans. Make up other ways of doing this.

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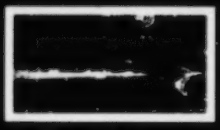

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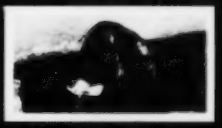

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